EFFECT OF NITROGEN FERTILIZER BROADCAST

AT DIFFERENT DATES ON AN AGING SEED STAND OF CREEPING RED FESCUE

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EFFECT OF NITROGEN FERTILIZER BROADCAST AT DIFFERENT DATES ON AN AGING SEED STAND OF CREEPING RED FESCUE

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The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Effect of Nitrogen Fertilizer Broadcast at Different Dates on an Aging Seed Stand of Creeping Red Fescue" submitted by Charles Robert Elliott in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

Fall applications of a nitrogenous fertilizer broadcast at different dates during the period August 15 to October 10 were equally effective in increasing the seed yields of creeping red fescue by increasing the number of panicles. The last fall treatment and treatments made the following spring prior to May 22, were effective in increasing number of seeds per head. The size of seed was increased by treatments made from May 8 to July 4. Subsequent treatments were not effective. The earliest indication that a growing point had been induced and initiated to the floral state was the presence of rudimentary inflorescence, observed on May 6, with a single row of protuberances on each of two sides. Secondary protuberances were noted on May 14 and individual floret primordia were beginning to develop by May 22. Heading occurred, on the average, on June 9.

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INTRODUCTION

One of the major problems encountered by producers of creeping red fescue seed is the reduction in yields as stands age. The application of nitrogen has increased seed yield but there is controversy regarding time of application. This problem is of economic importance to the seed producer who wants maximum utilization and minimum waste of supplementary plant nutrients.

In this report results of studies for determining the effect of fertilizing an aging seed stand of creeping red fescus at different dates will be reported. Stages of morphological development of the growing point were determined for each treatment date and will be used to interpret the effects of treatments.

LITERATURE REVIEW

Development of Inflorescence

Three principal phases of flowering in grasses have been reported (1, 13, 15, 16, 17, 18, 26, 32, 34). Lang (24) and Liverman (27) describe these phases as follows:

1. induction - a chemical or hormonal differentiation resulting from fulfilment of certain light and temperature requirements.
2. initiation - the morphological transformation of an induced growing point from a vegetative to a floral primordia.
3. complete development of the flowers.

Induction is obtained in many perennial grasses from the combination of low temperature and short photoperiods which occur naturally in the late autumn and early spring. Hanson and Sprague (18) found this to be so for orchard grass, meadow fescue, brome-grass and reed canary grass. After four weeks exposure to 8-hour days and a temperature of 35° F., these grasses headed when returned to days with 15 hours of light and temperatures of 70° F. Kentucky bluegrass was found to respond similarly by Peterson and Loomis (36). Timothy, however, was found to have no winter requirement for heading by Langer (25), Stapledon and Wheeler (43) and Gardner and Loomis (16). They showed that timothy readily formed heads after spring sowing.

Floral initiation was not recognized by many workers and was seldom worked with as a separate stage of flowering in grasses. Gardner and Loomis (16) working with orchard grass showed the requirements of this phase. They reported that any variation from the combination of factors normally encountered in the spring had adverse effects on the initiation of induced apical meristems. Usually the light and temperature factors essential for the development of panicles are also essential for initiation. Sass and Skogman (38) found inflorescences on bromegrass in late autumn in Ames, Iowa, but they did not survive the winter.

From preliminary observations the thermo-photoperiod requirements for induction and initiation in creeping red fescue are considered to be similar to those for Kentucky bluegrass in the Beaverlodge area (3). Panicles were not formed the year of seeding nor did they occur when plants were maintained under conditions of long days and warm temperatures in the greenhouse. Potted plants placed outside for four weeks during October 15 to November 15 produced seed if subsequently returned to the greenhouse environment.

Earlier investigations of the developmental morphology of the grass inflorescence were reviewed fully by Evans and Grover (14) who also reported their own findings with eight grass species. One of the earliest indications that an inflorescence is developing is the appearance of swellings or buds in distichous arrangement on the elongating shoot apex. In grasses with panicle-type inflorescences secondary swellings, or protuberances, develop at the base of the older ones and give rise to swellings of successively higher orders

(12, 14, 38). In grasses with spike-type inflorescences these secondary swellings do not give rise to structures of higher orders (8). Inflorescence development extends both up and down the apex. Cooper (8) reports that the primordia at the base of the inflorescence in quack grass continue to form leaves until the early floret stage of development. Sass and Skogman (38) noted in bromegrass that no more leaf primordia were formed after the initiation of the flower phase occurred. The apex tip was found to continue to add new primordia until it initiated the primordia which developed into the terminal structure (39).

The Effect of Nitrogen on Grass Seed Yields

Grass seed yields can generally be increased if nitrogen is made available, especially in older stands where often nitrogen deficiencies have developed. Evans (11) increased timothy seed yields with nitrogen at Ames, Iowa, as did Evans (10) with timothy, Canada bluegrass, orchard grass and meadow fescue at the Welsh Plant Breeding Station. North and Odland (35) and DeFrance and Odland (9) obtained yield increases from different species of bent grasses as a result of fertilizing with nitrogen. Burton (7) reported the same for 10 southern grasses. Musser (33) reported organic and inorganic sources of nitrogen were equally effective in increasing yields of creeping red fescue.

In greenhouse trials Evans and Wilsie (15) found that bromegrass plants receiving a complete nutrient solution produced 30 to 50 per cent more panicles than those receiving a nitrogen-deficient solution. Similarly, Sprague (41) found orchard grass produced a low yield of seed in a nitrogen-deficient soil.

Recent studies have shown that time of application is an important factor in fertilizing grass seed crops. Harrison and Crawford (19) obtained the highest seed yields and the greatest number of spikelets per panicle when bromegrass was fertilized on April 15. Treatments made one month later were equally effective in increasing the number of florets per spikelet but yields were lower. Bourg et al. (6) found early spring treatments (late March to early April) were more effective than autumn treatments on bromegrass in Nebraska while Anderson et al. (2) in Kansas obtained similar increases from both late fall and early spring treatments. Wilsie and Nelson (47) at Ames, Iowa, reported spring (March) applications more effective than fall (September). Splitting the treatment and placing one-half in the fall and the other half in the spring proved more effective than the full fall treatment but less effective than the full spring treatment. Contrary to these findings are results from Saskatoon where Knowles and Cooke (23) found August and September treatments were better than those made either in the late autumn or early spring.

McVicar and Gibson (28) reported no differences between a spring treatment and a split treatment of one-half in the fall and one-half in the spring on orchard grass at Ottawa. Stelfox et al. (45) found that fertilizer applied in the early spring of the previous year on Russian wild-rye at Saskatoon produced the greatest response. The same crop at Lacombe (44) showed a stronger response to June and August treatments than to those made in May or September.

Late fall treatments were reported by Knowles (22) to be superior for crested wheatgrass in Saskatchewan and by Anderson and Stacey (4) for creeping red fescue in Northern Alberta.

Klages and Stark (21) suggested fertilizing all grasses in the early spring before dormancy is broken.

Few workers attempted to associate nitrogen requirements with seasonal growth. Peterson and Loomis (36) clearly demonstrated the importance of having nitrogen available for Kentucky bluegrass during the short days when the highest carbohydrate accumulation normally occurs in plants. They concluded that this type of growth was associated with the ability of plants to initiate panicles. Newell's (34) work with bromegrass supported these findings. He concluded that late fall treatments were effective because the nitrogen was available when the plant started growth in the early spring. Gardner and Loomis (16) concluded that more efficient use was made of nitrogen applied to orchard grass when spring growth was active.

Referring to cereals Bayfield (5) suggested in 1932 that plants require a plentiful supply of readily available nitrogen all through the growing season to promote good growth and normal functions. McBeath (29), working with annual cereals on nitrogen deficient soils, noted increases in the number of heads per plant, seeds per head and seed size resulting from broadcast applications of a nitrogenous fertilizer during the early stages of plant growth. Similarly, Salt (37) observed increases in the number of heads on

winter wheat when nitrogen was applied on April 15, just prior to the time when winter wheat normally tillers.

The importance of having adequate moisture for the effective utilization of top-dressed nitrogen was referred to frequently in the literature (2, 6, 7, 11, 19, 22, 23, 28, 29, 45, 46).

MATERIALS AND METHODS

This study was conducted on a solid stand of creeping red fescue seeded alone at a rate of three pounds per acre on June 2, 1954, on the Experimental Farm at Beaverlodge, Alberta. The area sown had been summer fallowed in 1952 and 1953. The soil was classified as a degraded black loam to sandy clay loam (40).

A portion of the seeded field was divided into four equal areas of 98 feet by 150 feet each and were identified as Fields I, II, III and IV (Figure 1). Each field contained four replicates with 15 treatments per replicate in a randomized block arrangement. Individual plots were 10 feet by 20 feet.

The treatments consisted of a single application of ammonium nitrate (33.5-0-0) broadcast by hand at a rate of 100 pounds per acre. Treatment schedules provided for six treatment dates in the fall and eight dates the following spring and summer. The assigned treatment numbers and dates of application are presented in Table 1.

The management procedure for each field was as follows:
Field I - The fertilizer treatments commenced on September 3, 1954, three months after seeding, and stopped July 28, 1955. The first seed crop was harvested August 3, 1955. This schedule was repeated on Field I for each of the 1956, 1957 and 1958 harvests to provide information on the response of the stand to repeated fertilizer applications over a four-year period.

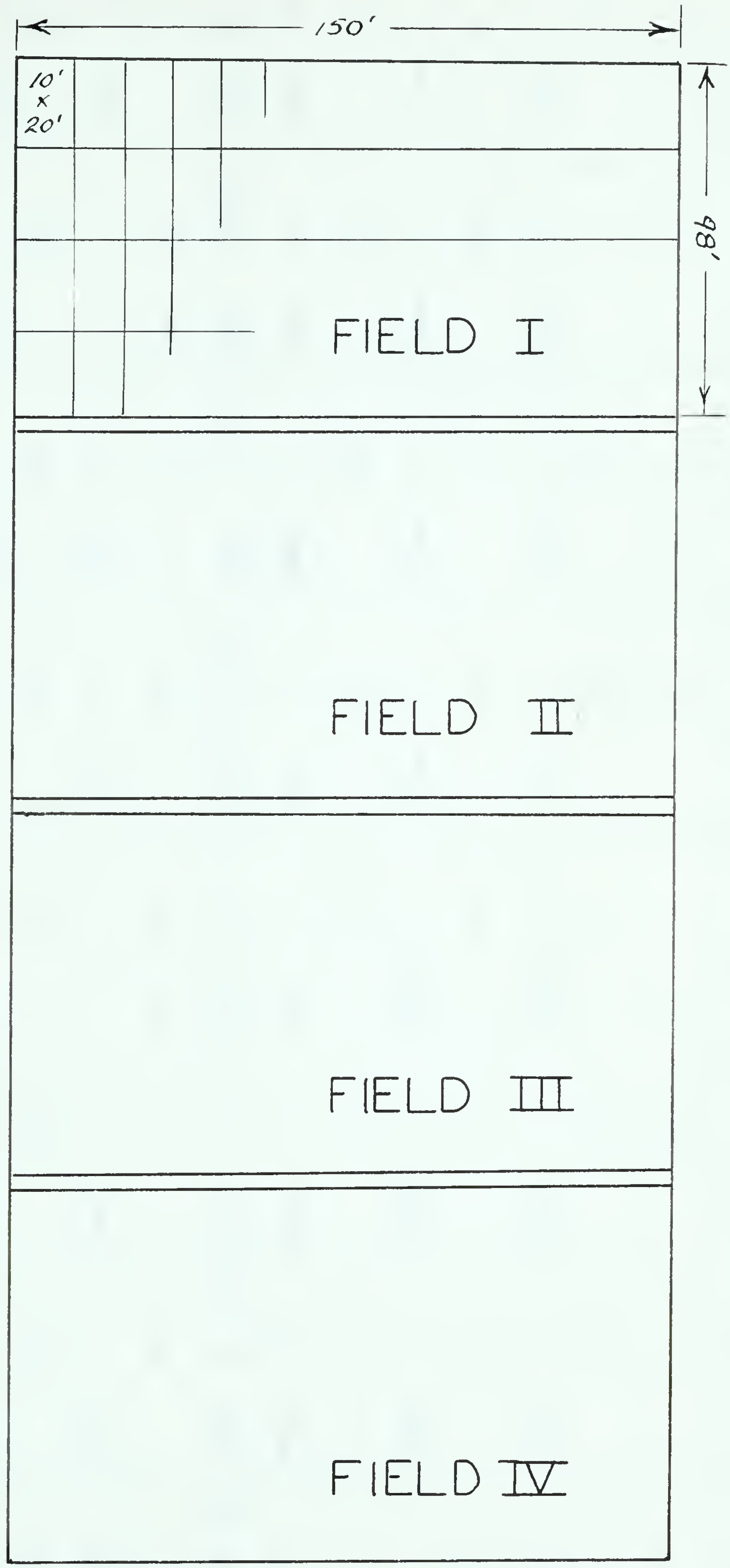

Figure 1. Layout of fields used for study of fertilizing creeping red fescue at different dates.

Table 1. Treatment and harvest dates

Treat. No.	Field I 1955	Field I 1956	Field I 1957	Field I 1958	Field II 1956	Field III 1957	Field IV 1958	Average date of treatment
1	--	Aug. 10 '55	Aug. 14 '56	Aug. 20 '57	--	--	Aug. 20 '57	Aug. 15
2	Sept. 3 '54	23	30	29	Aug. 23 '55	Aug. 30 '56	29	29
3	18	Sept. 6	Sept. 11	Sept. 10	Sept. 6	Sept. 11	Sept. 10	Sept. 10
4	Oct. 9	21	26	24	21	26	24	26
5	23	Oct. 4	Oct. 10	--	Oct. 4	Oct. 10	--	Oct. 10
6	Nov. 6	24	23	Oct. 29	24	23	Oct. 29	27
7	Apr. 20 '55	Apr. 25 '56	Apr. 23 '57	Apr. 29 '58	Apr. 23 '56	Apr. 23 '57	Apr. 29 '58	Apr. 25
8	May 3	May 8	May 8	May 13	May 8	May 8	May 13	May 8
9	17	22	22	27	22	22	27	22
10	June 1	June 5	June 4	June 11	June 5	June 4	June 11	June 4
11	14	19	17	26	19	17	26	20
12	28	July 4	July 3	July 8	July 4	July 3	July 8	July 4
13	July 11	18	18	--	18	18	--	17
14	28	31	30	--	31	30	--	30
15 (Check)								
Harvest dates	Aug. 3 '55	Aug. 6 '56	Aug. 7 '57	July 22 '58	Aug. 6 '56 Aug. 8 '57 July 22 '58	Aug. 15 '57 July 22 '58	July 22 '58	

Field II - Representing a two-year-old stand, Field II was introduced into the study on August 23, 1955, with treatments continuing to July 31, 1956. Seed yields from this field, harvested August 6, 1956, provided data on the effect of fertilizing for a second seed crop.

Field III - This field was introduced into the study August 30, 1956, with a treatment schedule that terminated July 30, 1957. Harvested August 15, 1957, seed yields measured the response of a three-year-old sod to applications of nitrogen.

Field IV - The seed harvested from this field on July 22, 1958, measured the effect of fertilizing a four-year-old sod during the period August 20, 1957, to July 8, 1958.

Subsequent harvests were taken from Fields II and III to observe residual effects of fertilizer treatments.

Soil moisture and pH were determined from a composite of four core samples taken from both the 0-6 inch and 6-12 inch depths of each plot immediately prior to the fertilizer applications. All soil samples were dried and stored in plastic bags until the collection was complete, at which time samples from the 0-6 inch depth, representing early spring, mid-summer and late fall for each year were analysed for nitrate nitrogen by the Spurway method (42).

Seed yields were determined by removing two swaths, three feet wide by 18 feet long, from each plot. The material was threshed, cleaned and recorded as pounds of clean seed per acre.

The number of panicles formed was determined by averaging four counts from each plot made within a metal frame which enclosed an area 12 inches by 24 inches. The counts were recorded as panicles per four feet of row.

Duplicate sets of 100 panicles each were taken at random from the unharvested portion of each plot in 1957 and 1958 (Fields III and IV). Each set was threshed by hand, the seed cleaned by a South Dakota Seed Blower (30) and checked on a diaphanoscope for cleanness. These samples were used to obtain data on weight per 1000 seeds, weight of seeds per 100 heads and per cent germination. Germination studies were conducted in the Plant Products Laboratory, Canada Department of Agriculture, Edmonton, according to the schedule normally followed by this agency (31).

Collections of plant material to study development of growing points were made on each treatment date and preserved in Carnoy's Fluid (20). Additional collections were made in the early spring of each year prior to the heading stage. Dissections were made under a stereoscopic binocular microscope and the stage of development determined according to the sketches in Figures 2, 3, 4 and 5. Microtome sections using the paraffin method were prepared from material collected during periods when developing inflorescences could not be readily identified by dissecting. Microtome sections were stained in safranin-fast green.

RESULTS AND DISCUSSION

The average precipitation for the period of this study was 17.45 inches. Except for a drought during the interval from early August to mid-October, 1955, precipitation was considered adequate and normally distributed. The drought in 1955 was reflected in the soil moisture which declined to 10.2 per cent in the 0-6 inch depth and 13.7 per cent in the 6-12 inch depth on September 6, 1955. All other soil moisture readings ranged from 16.4 to 34.0 per cent for the top six-inch layer and from 14.8 to 30.4 per cent for the bottom layer.

Soil pH averaged 6.1 for the 0-6 inch depth and 5.9 for the 6-12 inch depth for the four-year period. Other than a slight increase during the first year in both depths, soil pH remained fairly constant. Variations were not significant and could not be related to treatment effects.

Measurable quantities of nitrate nitrogen, averaging 23 pounds per acre, were found in the surface six inches of soil on September 2, 1954. As the stand aged the quantity of this nutrient declined. Only nine pounds per acre were found in the late autumn of 1954 and the early spring of 1955. On August 22, 1955, and on all subsequent treatment dates throughout the four-year study period, only trace amounts of nitrate nitrogen were found.

Development of the Inflorescence

The vegetative growing point of fescue has two to three ridges indicating leaf primordia on either of two sides as illustrated in Figure 2. As the lower ridges develop progressively into leaves, new ridges are formed near the shoot apex. All the growing points of new growth examined from heading to freeze-up were vegetative.

Panicles arose from the same growing points which had previously been developing leaves. The earliest morphological indications of initiation were the elongation of the growing point and a swelling of the ridges to form protuberances (Figure 3). This stage of development was noted on approximately May 6 by which time the shoot carried three to five new leaves. By May 14 of each year the initial protuberances were flanked on either side by smaller swellings and the entire point had increased in length (Figure 4). Rudimentary spikelets were observed on approximately May 22 (Figure 5) at which time internode elongation had placed the seed head about half way up the protective leaf sheath. Each year the panicles emerged approximately June 2 and commenced flowering within 10 days with no discernible variation between stands of different ages or treatments. The rate at which panicles completed flowering, developed seeds and ripened was dependent upon climatic conditions and varied considerably with each season as noted by the harvest dates (Table 1).

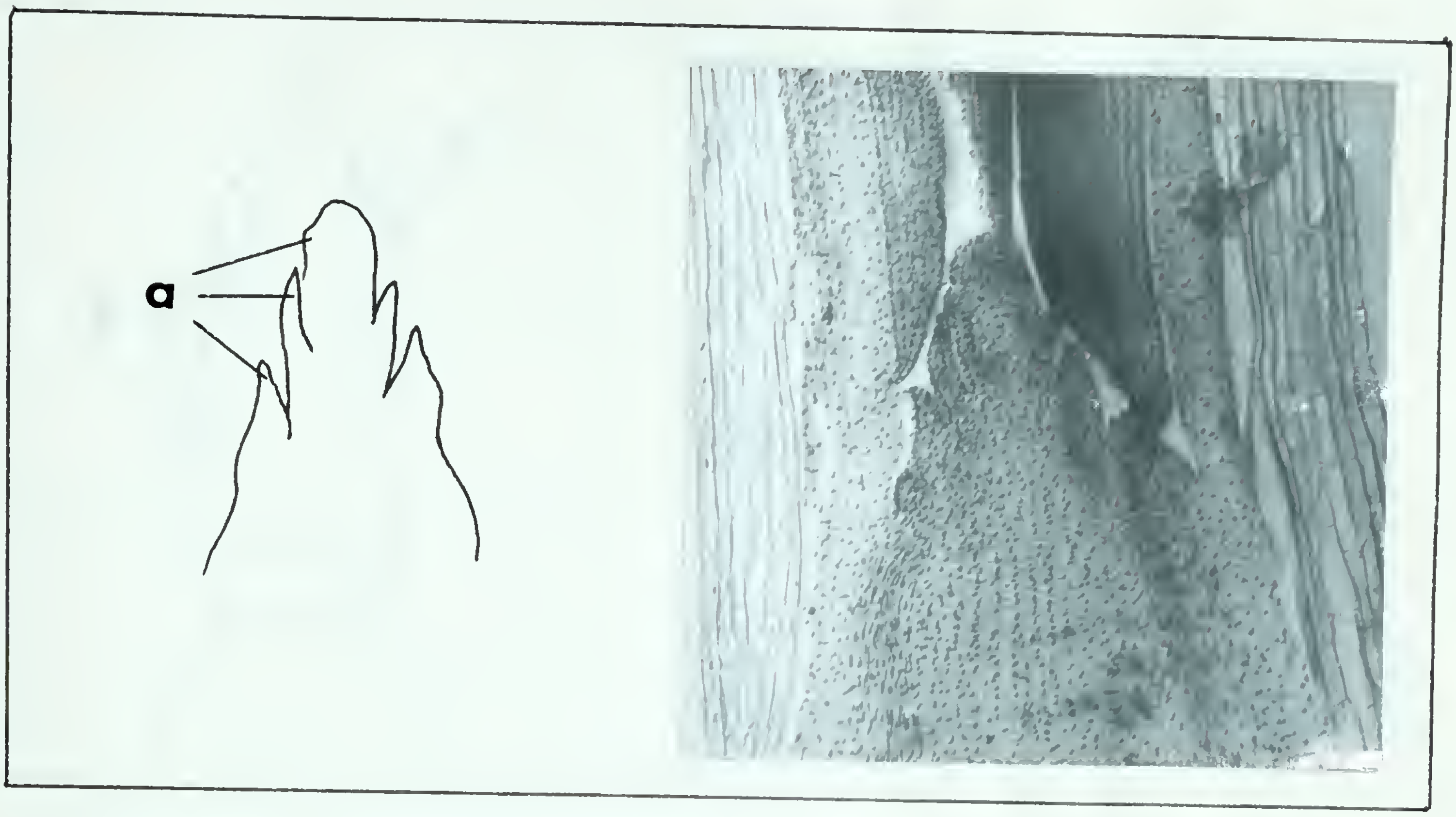

Figure 2. Vegetative growing point of creeping red fescue showing (a) leaf primordia.

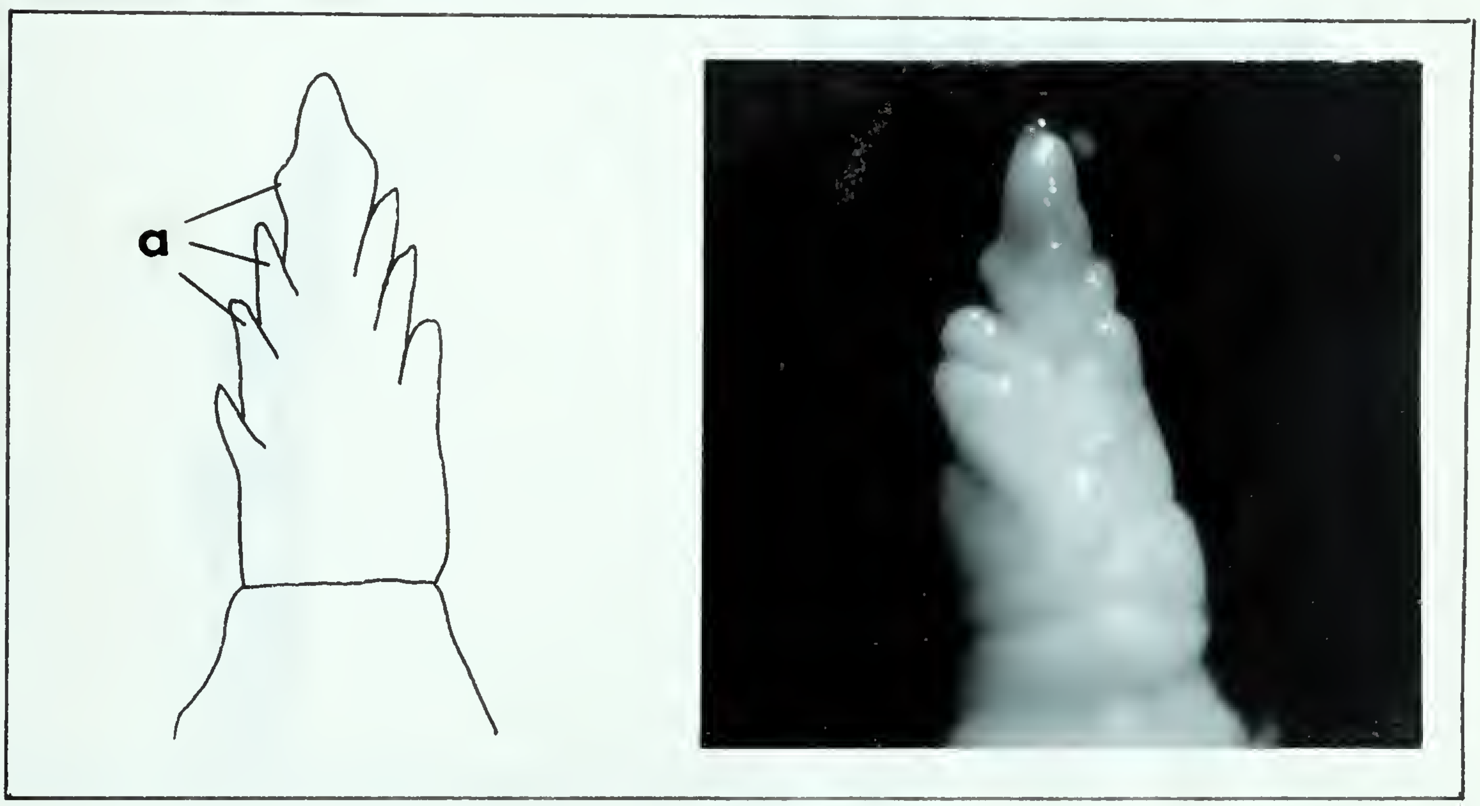

Figure 3. Rudimentary inflorescence of creeping red fescue, collected May 6, showing (a) first set of protuberances beginning to develop.

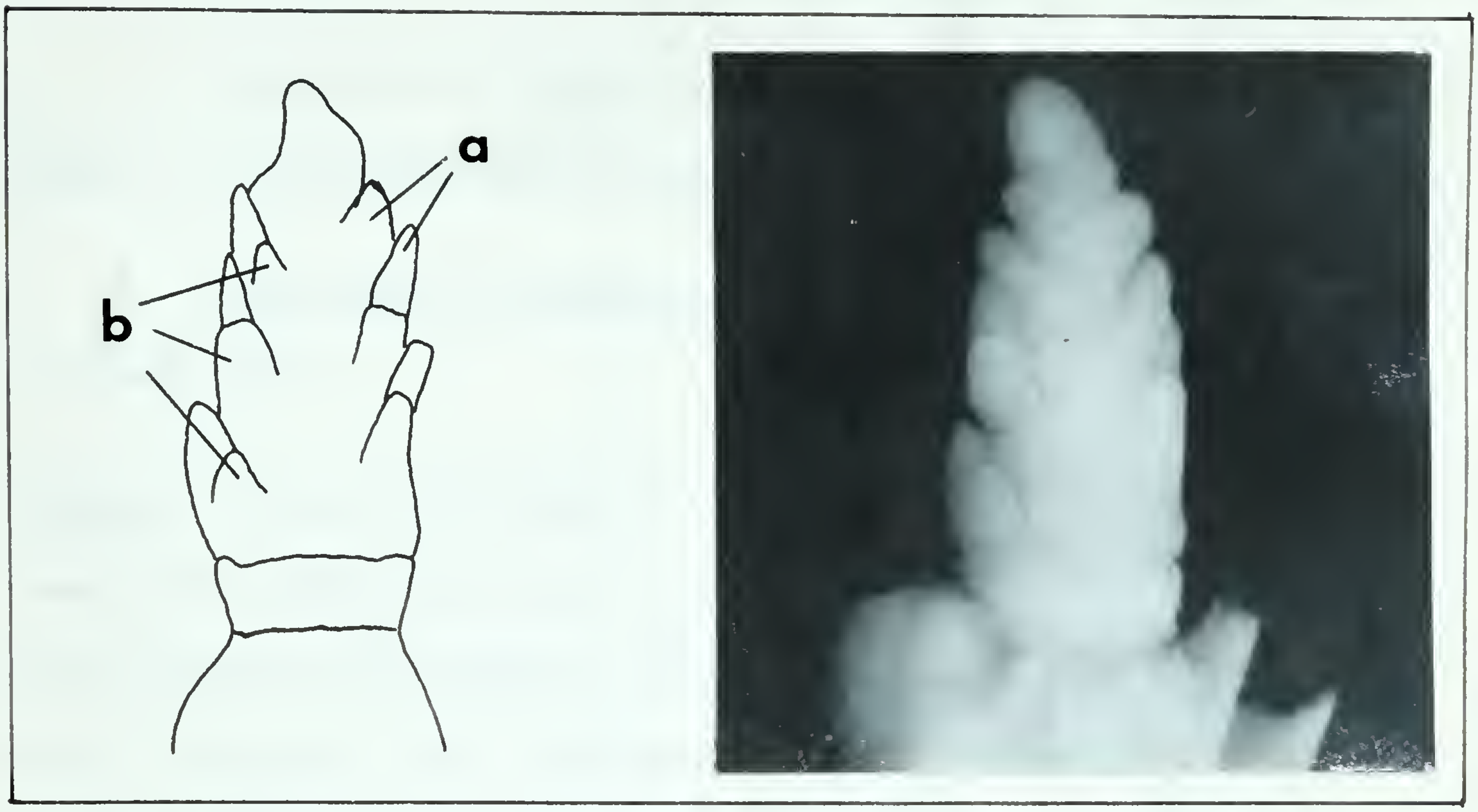

Figure 4. Rudimentary inflorescence of creeping red fescue, collected May 14, showing position of second set of protuberances (b) beginning to develop in either side of the older ones (a).

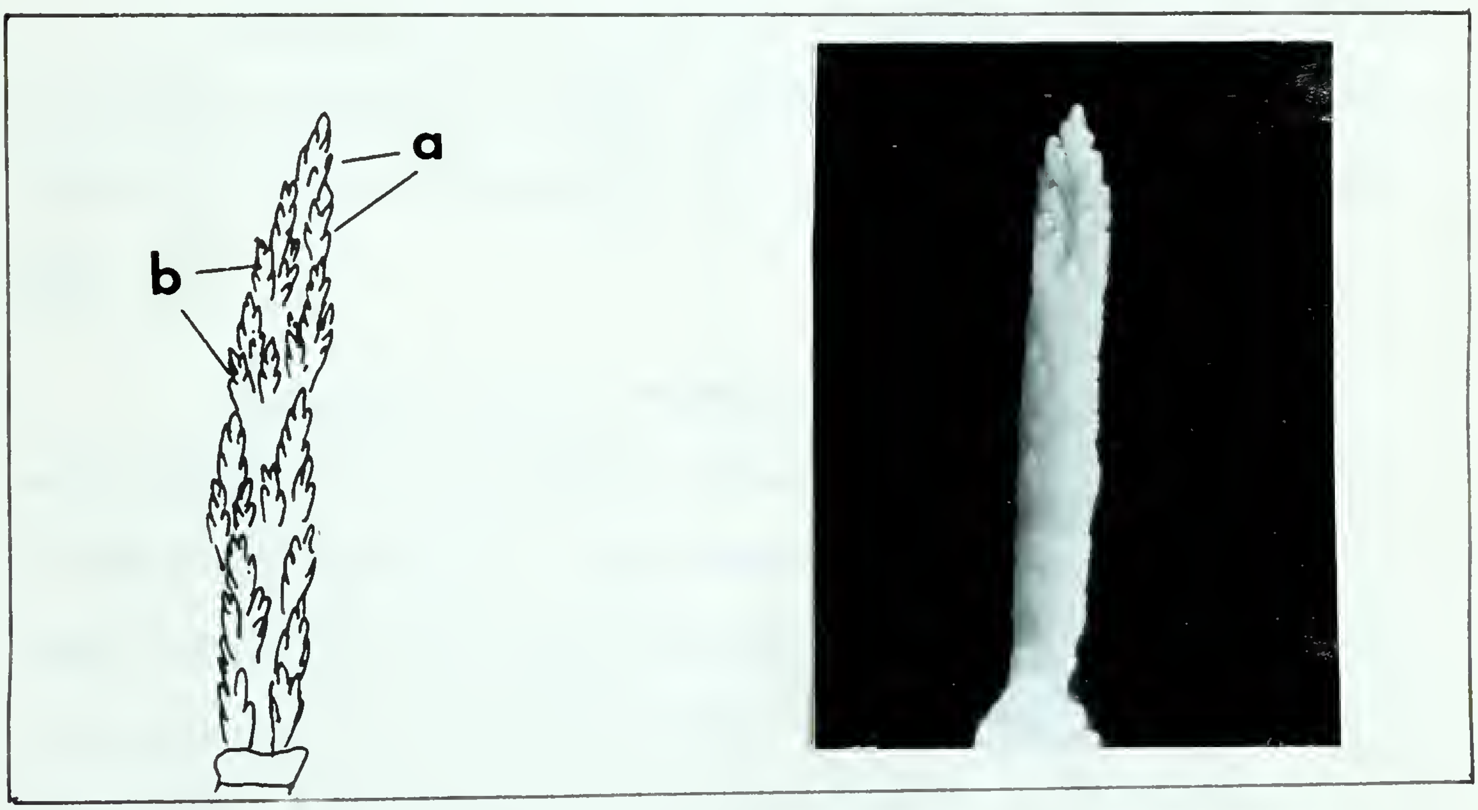

Figure 5. Rudimentary inflorescence of creeping red fescue, collected May 22, showing subdivision of protuberances (a) and (b) into individual floret primordia.

Treatment Effects

Misses in the proposed treatment schedules, as noted in Table 1, were necessitated by inclement weather and an early harvest.

The effect of treatments on seed yields will be discussed for each field.

Field I - In the late autumn of 1954 a slight abnormal twisting of some of the leaves was noted on plots which had been fertilized. This indicated that ammonium nitrate, at the rate of 100 pounds per acre, was toxic to the young grass plants. The damage was reflected in lower yields in the first seed crop, harvested in 1955, although seed yield depression was not significant for any specific treatment date (Table 2).

Treatments failed to promote a significant yield increase on the plots harvested in 1955, indicating that the soil contained sufficient nitrate nitrogen for the requirements of the first seed crop.

Yield data for the second seed crop, harvested in 1956, were extremely low and failed to present differences attributable to fertilizer treatments. The drought in 1955 was credited with these low yields which were obviously abnormal and were, therefore, not considered in the interpretation of treatment effects. On the other hand, the 1956 yield data demonstrate the dependence of a fescue seed crop on adequate moisture supplies during the pre-harvest year.

Table 2. Seed yields in pounds per acre - Field I

Treatment No.	1955	1956	1957	1958	Treatment means 1955, 1957 & 1958
1	-	7	112**	4	-
2	452	19	125**	4	194
3	464	14	112**	5	194
4	459	14	116**	2	192
5	458	10	115**	-	-
6	462	6	126**	6	198
7	538	5	75**	3	205
8	539	21	48	2	196
9	512	22	44	8	188
10	521	12	41	9	190
11	513	24	45	8	189
12	512	20	51	4	189
13	545	12	63	-	-
14	496	15	71*	-	-
Check	504	12	52	5	187
Average	492	14	78	5	193
Av. treatments 1 to 6	453	12	115	4	194
Av. spring treatments 7 to 14	514	17	49	6	193
L.S.D. .05	N.S.	N.S.	15	N.S.	N.S.
.01	N.S.	N.S.	20	N.S.	N.S.
Pre-winter vs. post-winter	-	-	**	-	-
Years L.S.D. .05					56
.01					72
Treatments x years - between 2 treatments in same year L.S.D.					.05 54
					.01 N.S.
-between 2 years in same treatment					.05 74
					.01 N.S.

* Significant at the 5 per cent level

** Significant at the 1 per cent level

By 1957 the initial nutrient reserve had been depleted to a level where fall treatments promoted highly significant seed yield increases in the third crop. Increases were also recorded for treatment Number 7 (April 25) and treatment Number 14 (July 30). The increase from treatment Number 14 is considered a residual effect from the 1956 treatment on the same plot. Pre-winter treatment means as a group exceeded post-winter treatment means beyond the one per cent level of significance in 1957.

After four growing seasons the stand had thickened to form an almost solid turf with no further evidence of rows. The nutrient requirements of this solid turf apparently exceeded the levels supplied by treatments used and no treatment effects were noted.

To examine the overall effects of treatments on seed yields in Field I, the yields of 1955, 1957 and 1958 were analysed on split-plot basis. For this comparison only those treatments made in each year were used. The inconsistent response to fertilizer treatments resulted in non-significant yield differences for the treatment main effect. This is accounted for by fall treatments causing yield decreases in 1955 and yield increases for 1957. The decline in yields as the stand aged created highly significant differences between years. Considering treatments within years, significant differences were noted only in 1957 where all fall treatments exceeded the check. Comparisons could be made between the same treatments in different years but they are of little value to this study.

<u>Field II</u> - Seed yield data for Field II (Table 3), as mentioned earlier, were rendered invalid by drought. A subsequent harvest

Table 3. Seed yields in pounds per acre - Field II

Treatment No.	1956	1957	1958
1	-	-	-
2	22	23	21
3	20	22	20
4	23	27	13
5	28	29	29
6	18	18	16
7	28	17	22
8	30	15	14
9	19	17	20
10	22	28	18
11	24	34	9
12	26	34	12
13	20	46**	14
14	16	73**	11
Check	20	18	24
Average	23	29	17
Av. treatments 1 to 6	22	24	20
Av. treatments 7 to 14	25	24	16
L.S.D. .05	N.S.	18	N.S.
.01	N.S.	24	N.S.
Pre-winter vs. post-winter	-	-	-

* Significant at the 5 per cent level

** Significant at the 1 per cent level

taken in 1957, however, revealed highly significant yield increases for treatments Number 13 and Number 14. Again, as with Field I, these increases are attributed to fertilizer treatments made the previous year. The carry-over, however, did not extend into the third harvest made in 1958.

Field III - Harvested in 1957, seed yield data from Field III (Table 4), representing a third seed harvest, showed highly significant yield increases for each of the fall treatments. Significant increases were also recorded for treatments Numbers 7 and 8. Pre-winter treatment means as a group exceeded the post-winter means beyond the one per cent level of significance in Field III as was noted for the 1957 data from Field I.

Residual effect from the 1957 treatments Numbers 13 and 14 were noted in the 1958 harvest from Field III.

Field IV - Slight yield increases from fall treatments were noted in the yield data from Field IV harvested in 1958, but these were not significant (Table 5). As with the 1958 harvest in Field I, the failure of treatments to create a response in this fourth seed crop is attributed to the age of the sod which had become very dense and had undoubtedly depleted nutrient resources. Again, it is likely that the level of nitrogen application was not high enough to give a response.

Table 6 presents a summary of seed yield data for the first harvest year of each field. For this comparison only those treatments made in each of Field I, III and IV were used. Field II was

Table 4. Seed yields in pounds per acre - Field III

Treatment No.	1957	1958
1	-	-
2	115**	11
3	140**	19
4	122**	16
5	128**	18
6	120**	16
7	70*	29
8	61*	37
9	50	35
10	47	42
11	40	39
12	29	43
13	23	63*
14	25	72**
Check	30	40
Average	72	34
Av. treatments 1 to 6	137	16
Av. treatments 7 to 14	49	37
L.S.D. .05	31	18
.01	42	25
Pre-winter vs. post-winter	**	-

* Significant at the 5 per cent level

** Significant at the 1 per cent level

Table 5. Seed yields in pounds per acre - Field IV

Treatment No.	1958
1	50
2	34
3	44
4	37
5	-
6	35
7	28
8	28
9	26
10	20
11	26
12	30
13	-
14	-
Check	24
Average	32
Av. treatments 1 to 6	40
Av. treatments 7 to 12	26
L.S.D. .05	N.S.
.01	N.S.
Pre-winter vs. post winter	-

Table 6. Summary of first harvest seed yields from Fields I, III & IV

Treatments	I	III	IV	Treatment means
2	452	115*	34	200
3	464	140*	44	216
4	459	122*	37	206
6	462	120*	35	206
7	538	70	28	212
8	539	61	28	209
9	512	50	26	196
10	521	47	20	196
11	513	40	26	193
12	512	29	30	190
Check	504	30	24	186
Year Means	498	75	30	201

L.S.D.	.05	.01
Treatments	N.S.	N.S.
Years	60	91
Treatments x years		
Between 2 treatments in same year	74	N.S.
Between 2 years in same treatment	85	N.S.

* Significant at the 5 per cent level

** Significant at the 1 per cent level

not included for reasons given earlier. The inconsistent response to fertilizer treatments resulted in non-significant yield differences for the treatment main effect. This is accounted for by fall treatments causing yield decreases in Field I and yield increases in Fields III and IV. Differences between fields were highly significant with Field I outyielding the other two. Although yields declined as the stand aged, the difference between Field III and Field IV was not significant. Considering treatments within fields, differences were noted only in Field III where all fall treatments exceeded the check. Comparisons can be made between the same treatments in different fields but they are of little value to this study.

Panicle count data (Table 7) reflect the same treatment effects noted in the seed yield data which indicates that seed yields were increased through fertilizing primarily because the number of panicles was increased. The correlation is so obvious that little or no further comment is considered necessary.

When treatment effects were measured by the weight of 1000 seeds (Table 8), a different response was noted. Increases occurred in Field III for all but the first treatment with the strongest response resulting from treatments Number 8 to Number 12, inclusive. The same trend was noted in Field IV but the differences failed to reach significance. However, a split-plot analysis of these data showed that the increases in weight per 1000 seeds, resulting from treatments Numbers 8, 9, 10, 11 and 12, were highly significant. The non-significant Treatments x Fields interaction indicates the same treatments were effective in increasing seed weight in both fields.

Table 7. Panicles per four feet of row

Treatment No.	Field I				Field II		Field III	Field IV
	1955	1956	1957	1958	1956	1957	1957	1958
1	-	3.74	112*	13	-	-	-	41*
2	308	8.04	130**	16	9.95	63	118**	50**
3	400	6.58	121*	20	9.08	57	106**	49**
4	284	5.77	114*	12	9.12	48	99**	41*
5	360	4.91	113*	-	10.14	54	103**	-
6	312	3.04	130**	20	6.92	44	101**	42*
7	424	2.88	105*	9	9.65	59	66*	34
8	352	8.14	96	14	10.16	51	61	29
9	328	9.29	83	24	6.30	52	42	24
10	348	5.74	52	22	8.05	54	44	26
11	352	10.48	76	21	8.62	68	43	22
12	388	8.84	85	16	9.68	58	37	25
13	328	7.19	74	-	8.43	78*	46	-
14	312	9.37	92	-	6.55	91*	42	-
Check	384	9.44	60	11	9.32	52	44	26
Average	348	6.90	91	16	8.64	59	64	31
Av. treatments 1 to 6	333	5.33	110	16	9.04	-	99	37
Av. treatments 7 to 14	365	7.55	77	18	8.75	-	45	27
L.S.D. .05	N.S.	N.S.	39	N.S.	N.S.	22	20	14
.01	N.S.	N.S.	52	N.S.	N.S.	N.S.	27	19
Pre-winter vs. post-winter	N.S.	N.S.	**	N.S.	N.S.	-	**	N.S.

* Significant at the 5 per cent level

** Significant at the 1 per cent level

Table 8. Weight of 1000 seeds (grams)

Treatment No.	Field III	Field IV	Treatment means
1	-	1.0565	-
2	1.1362	1.1078	1.1220
3	1.2048	1.0925	1.1486
4	1.1660	1.1002	1.1332
5	1.2038	-	-
6	1.1878	1.0688	1.1283
7	1.1057	1.1448	1.1252
8	1.2190	1.1652	1.1921**
9	1.2242	1.1747	1.1994**
10	1.2212	1.1715	1.1964**
11	1.2765	1.1682	1.2223**
12	1.2507	1.1121	1.1814**
13	1.1982	-	-
14	1.1520	-	-
Check	1.1400	1.0640	1.1020
Average	1.1919	1.1114	1.1597
Av. treatments 1 to 6	1.1797	1.0852	1.1330
Av. treatments 7 to 14	1.2162	1.1411	1.1861
L.S.D. .05	0.0087	N.S.	0.0592
.01	N.S.	N.S.	0.0787
Pre-winter vs. post-winter	N.S.	*	N.S.
Years			N.S.
Years x treatments			N.S.

* Significant at the 5 per cent level
** Significant at the 1 per cent level

The weight of seed per 100 panicles (Table 9) was also increased by some treatments. In Field IV increases could be attributed to the last treatment in the fall (Number 6) and the first three the following spring (Numbers 7, 8 and 9). Field III data showed the same trend but differences were not significant. An analysis of the combined data for Fields III and IV showed the increases from treatments Numbers 6 to 9, inclusive, to be significant with both fields conforming. Although the number of seeds per panicle was not determined the increase in weight per 100 panicles can be interpreted as primarily an increase in the number of seeds per panicle since the effective treatment dates did not coincide with dates most effective in increasing the weight per 1000 seeds.

The average germination for the seed harvested from Fields III and IV was 85.6 per cent. Fertilizer treatments did not influence seed germination.

Table 9. Weight of seed per 100 heads (grams)

Treatment No.	Field III	Field IV	Treatment means
1	-	3.1083	-
2	4.9040	2.8716	3.8878
3	5.2134	3.1366	4.1750
4	5.5917	3.7851	4.6884
5	6.3263	-	-
6	6.4444	4.9376	5.6910**
7	5.7396	5.2071	5.4733**
8	7.4077	5.0114	6.2096**
9	6.1042	4.7682	5.4362**
10	6.1404	3.7304	4.9354
11	4.9971	4.1303	4.5637
12	4.9873	3.6761	4.3319
13	4.2200	-	-
14	4.8481	-	-
Check	4.1491	3.3701	3.7596
Average	5.5052	3.9559	4.8320
Av. treatments 1 to 6	5.6960	3.4916	4.6106
Av. treatments 7 to 14	5.8960	4.4454	5.1584
L.S.D. .05	N.S.	1.1987	1.2542
.01	N.S.	1.6142	1.6681
Pre-winter vs. post-winter	N.S.	N.S.	N.S.
Years L.S.D. .05			0.8353
.01			1.5333
Years x treatments			N.S.

* Significant at the 5 per cent level
** Significant at the 1 per cent level

CONCLUSIONS

During the growing season creeping red fescue produces new shoots from which foliar growth arises. With adequate moisture and nutrients the growing points of these shoots attain a specific physiological condition which permits them to become induced to produce panicles the following season. No attempt was made to determine the time of induction, that is, whether it takes place in the late fall or early spring. However, the time of morphological transformation from the vegetative growing point to the floral growing point was established as approximately May 6 for material under study at Beaverlodge. Rudimentary panicle branches were observed May 14 and subdivisions identified as floret primordia were noted May 22. All the growing points observed in the early spring prior to May 6 and during the growing period May 22 to freeze-up were vegetative.

The summer-fallowed land into which the creeping red fescue for this study was seeded contained sufficient nitrate nitrogen to meet the requirements of the first seed crop and treatments of supplementary nitrogen were ineffective. Indeed, treatments made the year of seeding caused malformed foliar growth and possibly resulted in lowered seed yields. As the stand aged and available soil nitrogen was depleted to only trace amounts increases of seed were obtained with fertilizer applications. The nitrogen requirements of the dense, four-year-old sod probably exceeded the levels supplied by treatments used and responses were negligible.

All fall treatments were equally beneficial in increasing seed yields by increasing the number of heads. Plots treated in the early fall responded within 10 to 12 days by producing a darker green and more robust foliage indicating nitrogen assimilation. This foliage was not analyzed chemically but it was pointed out by Peterson and Loomis (36) and Newell (34), working with bluegrass and bromegrass respectively, that under conditions of short days and high levels of nitrogen the highest levels of nitrogen and carbohydrate accumulation occurred in the plant, a type of growth which is associated with the ability of the plant to initiate panicles. On the other hand, plots treated just prior to freeze-up also produced well. Fall assimilation of nitrogen by these plants would have been obviously restricted by freezing temperatures, short days, and often snow cover. It is, therefore, concluded that the critical period with regard to nitrogen requirements for fescue seed production is in the early spring when the dormancy is broken. New growth can be found almost as soon as the snow cover melts and the frost leaves the soil. Fertilizer applied just prior to freeze-up would be utilized at this time.

The first spring treatment was delayed until the plot area was dry enough to work without injury to the sod and was only slightly effective in increasing panicles. This indicates that the initiation period with the proper combination of light and temperature had almost passed and only a few growing points responded when nitrogen was added.

Treatments which increased the number of seeds per panicle were those which supplied nitrogen for the initiation of individual

floret primordia within the developing panicle, a stage most obvious on May 22. Treatments later than this were not effective.

Similarly, treatments which supplied nitrogen to the heading plant were effective in increasing the weight of the seed. Treatments 13 and 14 were made during the ripening process and did not produce a measurable response probably because assimilation and translocation were diminishing.

On reviewing all treatments it is concluded that the nitrogen supplied by treatment Number 6 in the late autumn was utilized the most efficiently in that it increased both the number of panicles and the number of seeds per panicle. This treatment indicates the appropriate time for seed producers to fertilize fescue fields.

It is conceded that this study utilized only single annual treatments. Since the greatest production would be expected from plants in a constant state of good health it is suggested that a natural follow-up study would involve two or more fertilizer applications per year.

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